1986-12

An analysis of cost analysis methods used during contract evaluation and source selection in government contracting

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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

AN ANALYSIS OF COST ANALYSIS METHODS USED DURING CONTRACT EVALUATION AND SOURCE SELECTION IN GOVERNMENT CONTRACTING

by

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December 1986

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REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited
2b DECLASSIFICATION/DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBER(S)	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION Naval Postgraduate School 6b OFFICE SYMBOL (*If applicable*) Code 54	7a NAME OF MONITORING ORGANIZATION Naval Postgraduate School
6c ADDRESS (*City, State, and ZIP Code*) Monterey, California 93943-5000	7b ADDRESS (*City, State, and ZIP Code*) Monterey, California 93943-5000
8a NAME OF FUNDING/SPONSORING ORGANIZATION 8b OFFICE SYMBOL (*If applicable*)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c ADDRESS (*City, State, and ZIP Code*)	10 SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO

11 TITLE (*Include Security Classification*)
AN ANALYSIS OF COST ANALYSIS METHODS USED DURING CONTRACT EVALUATION AND SOURCE SELECTION IN GOVERNMENT CONTRACTING

12 PERSONAL AUTHOR(S)
Donaldson, Morgan L.

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (*Year, Month, Day*)	15 PAGE COUNT
Master's Thesis	FROM _____ TO _____	1986, December	94

16 SUPPLEMENTARY NOTATION

17 COSATI CODES			18 SUBJECT TERMS (*Continue on reverse if necessary and identify by block number*)
FIELD	GROUP	SUB-GROUP	Cost Analysis; Contract Proposal Evaluation

19 ABSTRACT (*Continue on reverse if necessary and identify by block number*)

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20 DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION Unclassified
22a NAME OF RESPONSIBLE INDIVIDUAL Prof. David V. Lamm	22b TELEPHONE (*Include Area Code*) (408) 646-2775 22c OFFICE SYMBOL Code 54Lt

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted
All other editions are obsolete

#19 - ABSTRACT - (CONTINUED)

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An Analysis of Cost Analysis Methods Used During Contract Evaluation and Source Selection in Government Contracting

by

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Submitted in partial fulfillment of the
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MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
December 1986

ABSTRACT

The Federal Acquisition Regulations prescribe certain analytical tools and procedures to be used and followed by the Government contracting officer in his determination of a fair and reasonable price that the Government should pay for required goods and services. This determination is made during the contract evaluation and source selection phase of the acquisition process.

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I. INTRODUCTION

> The objective of procurement is to secure needed supplies and services from responsible sources at fair and reasonable prices calculated to result in the lowest ultimate overall cost to the government. [Ref. 1:p. 2-1]

This seemingly simple and rational definition from the Federal Acquisition Regulations is the focus of this thesis.

The Federal Procurement Process can be divided into six sequential stages.

1. Procurement Planning
2. Solicitation
3. Contract Proposal Evaluation and Source Selection
4. Negotiation
5. Contract Award
6. Contract Administration

Although all are equally important, this study will concentrate upon the third stage of the process, as it relates to the procurement of Department of Defense (DOD) weapon systems during the last stage of the acquisition cycle, production and deployment. For it is during the contract evaluation and source selection stage that the contracting officer must use prescribed analytical tools to determine what is a fair and reasonable price calculated to result in the lowest ultimate overall cost to the Government.

Broadly speaking, there are two different methods of contract proposal evaluation; price analysis and cost analysis. There are several different source selection methods that the Federal Government uses. Among these are the two step, three step, and four step methods. While the foundations that these various methods are based upon appear to be firm, one must wonder why additional analytical tools are periodically advocated. In recent years we have seen should cost analysis prescribed by the Fiscal Year 1986 Department Of Defense Authorization Act for all major defense systems acquisitions. Cost realism is another concept that has become more prominent in the procurement literature and Department Of Defense [DOD] regulations [Ref. 1:p. 3-53].

One must ask, in light of these trends to prescribe new analytical methods, whether our basic analytical tools are adequate for the task. Or has the procurement environment become sufficiently complex to warrant the use of other methods, such as should cost and cost realism?

This thesis will explore these questions through an evaluation of current analytical tools and methods. Additionally, if it is found that these tools are lacking, thus warranting the use of other tools or methods, this thesis will suggest alternatives that may strengthen our ability to analyze and select contract sources.

A. RESEARCH QUESTIONS

The primary question to be addressed in this thesis is: What are the methods used, with regard to cost, to analyze contract proposals and conduct source selection, and how effective are they?

The subsidiary questions are:

1. What is should cost analysis, and what is its role in contract proposal evaluation?
2. What is cost realism, and what is its role in the source selection process?
3. How can the contract evaluation and source selection process be improved to insure the Government receives a fair and reasonable price calculated to result in the lowest ultimate overall cost to the Government?

B. OBJECTIVES

The objective of this thesis is to examine and answer the research questions. Moreover, the interest here is also to spark further research into the foundations upon which current methods of contract evaluation and source selection are based. It is apparent through the development of should cost analysis and cost realism, that our current methods of analysis may be insufficient. If this is in fact the case, then it is time to re-evaluate the assumptions that our methods are based upon.

C. SCOPE OF THE THESIS

Price analysis, one of the two different analytical techniques used to evaluate contract proposals, refers to

the analysis of the price of the proposal without regard to its component elements of cost. Price analysis is used on all procurements regardless of the type of procurement (sealed bid or competitive proposal).

Cost analysis, the second method used to evaluate contract proposals, involves the analysis of the individual cost elements that comprise the price. Cost analysis is used when competition has been ineffective, or suspected of being ineffective. Cost analysis naturally can only be used for a competitive proposal procurement.

Should cost analysis is a cost analysis technique, but hardly a typical technique that is regularly used. Rather it is an exceptional technique that is prescribed for use in procurements whose dollar value is very large, and there is suspicion of less than efficient contractor production.

This thesis will broadly examine the regulatory requirements for price and cost analysis, as well as the use of should cost analysis. Additionally, it will examine the circumstances that warrant the use of such an exceptional technique as should cost.

Furthermore, the thesis will broadly examine the source selection process and the way in which the results of the contract evaluation process are used to make the source selection decision. In this regard cost realism will be discussed. Cost realism is an evaluation criterion in the

source selection process, but it, like should cost analysis, is not typically used in most procurements.

After examining the regulatory requirements, this thesis will then attempt to evaluate the effectiveness of contract evaluation and source selection methods. In this regard, weaknesses in these methods will be identified. Finally, an alternative method, that can be used to compensate for the identified weaknesses, will be offered.

D. ORGANIZATION OF THE THESIS

This thesis will start by first reviewing the requirements for contract proposal evaluation in the FAR. It will then examine the economic principles that support the two methods required; price and cost analysis. The thesis will then address the place of should cost analysis in contract proposal evaluation. This analysis will explore the history of should cost analysis and the current requirement for should cost studies.

Part III of this thesis will look at the source selection process. This analysis will draw upon the requirements of the FAR, as well as the Department of Defense Acquisition Regulations [DFAR], the Navy Acquisition Regulations Supplement [NARSUP], and DOD and Navy Regulations. It will then look at cost realism and its role in current source selection methods.

Part IV of this thesis will draw some conclusions about the effectiveness of the aforementioned procedures and

methods. It will also indicate where, and why improvements are warranted.

Part V will offer what is deemed to be a more satisfactory means of evaluating contract proposals and selecting contract sources. This analysis is based upon a marginal analysis of proposed direct costs. By analyzing a contractor's proposed marginal costs of production, the relative efficiency of competing offerors could be determined. This factor could in turn be used in special circumstances as a source selection criterion.

Finally, this thesis will recommend circumstances during which marginal analysis of contractor proposed production costs could be used.

II. CONTRACT PROPOSAL EVALUATION

A. PRICE ANALYSIS

Price analysis, in its broadest sense, is: "The examination of a seller's price without examination and evaluation of the separate elements of the cost and profit making up the price." [Ref. 2:p. 161]

In addition to being relatively inexpensive and easy to conduct, price analysis is always conducted the same way. It always involves the comparison of the bottom line price with another price. In the competitive arena, either sealed bid or competitive proposal, the bottom line of each bid or offer is compared with one another. Various other comparisons may also be made depending upon the dollar value of the procurement involved. Among these other comparisons are: [Ref. 3:pp. 15-35]

1. Comparison of prior proposed prices and contract prices with current proposed prices for the same or similar items.
2. Application of rough yardsticks (such as dollars per pound or per horsepower, or other units) to highlight significant inconsistencies that warrant additional pricing inquiry.
3. Comparison with competitive published price lists, published market prices of commodities, similar indexes, and discount or rebate arrangements.
4. Comparison of proposed prices with independent Government cost estimates.

If the procurement is noncompetitive, extra care must be taken because comparison of proposed prices received in response to the solicitation cannot be done. More attention must be paid to the other means of price comparison.

As stated in the FAR, price analysis is conducted on all procurements to ensure that the overall price is fair and reasonable. [Ref. 3:p.15-35] This begs the question, "What then do we mean by a fair and reasonable price?" The answer to this question can be found in the Armed Services Pricing Manual [ASPM].

> A fair and reasonable price is . . . one that is fair to both parties, considering the promised quality and timeliness of contract performance. Thus, to be fair to both parties, the price must represent a reasonable compromise between the seller's and the buyer's view of a fair price. [Ref. 1:p. 2-6]

The ASPM goes on to state that a fair and reasonable price should be considered in three dimensions: fair under current market conditions; reasonable to the seller; and reasonable to the buyer.

Let us now consider the economic foundations of the three dimensions within which a fair and reasonable price is determined: the market, the buyer, and the seller.

Markets can be theoretically described in degrees of competition. They can range from perfectly competitive to imperfect. A perfectly competitive market is characterized by four conditions. First the product of any one seller is the same as the product of any other seller. That is, the

items are homogeneous and perfectly interchangeable. Secondly, each buyer or seller in the market, is so small in relation to the entire market, that he or she cannot affect the product's price. Buyers and sellers are thus price takers. Third, buyers and sellers, and their resources, are free to enter and leave the market at will. Lastly, buyers and sellers have perfect knowledge of market prices, and relevant economic and technological data [Ref. 4:pp. 232-233].

In this perfectly competitive market, the market price and quantity will be determined by the aggregate forces of supply and demand. In the short run (a condition in which capital assets are fixed), these constantly changing forces will repetitively define and redefine the market price and quantity. As the market price and quantity is constantly changing, an equilibrium price is never reached. Rather the market tends toward an equilibrium price, but never reaches it.

This cycle within which the competitive market tends towards equilibrium price is illustrated in Figure 1. If the market demand is represented by line D1 and the market supply by line S1, then market price will be OP1 at quantity OQ1. If another supplier enters the market with a supply function represented by line S2, then the new price will be reestablished at price OP2 and quantity OQ2. Price and quantity produced are thus established by the aggregate

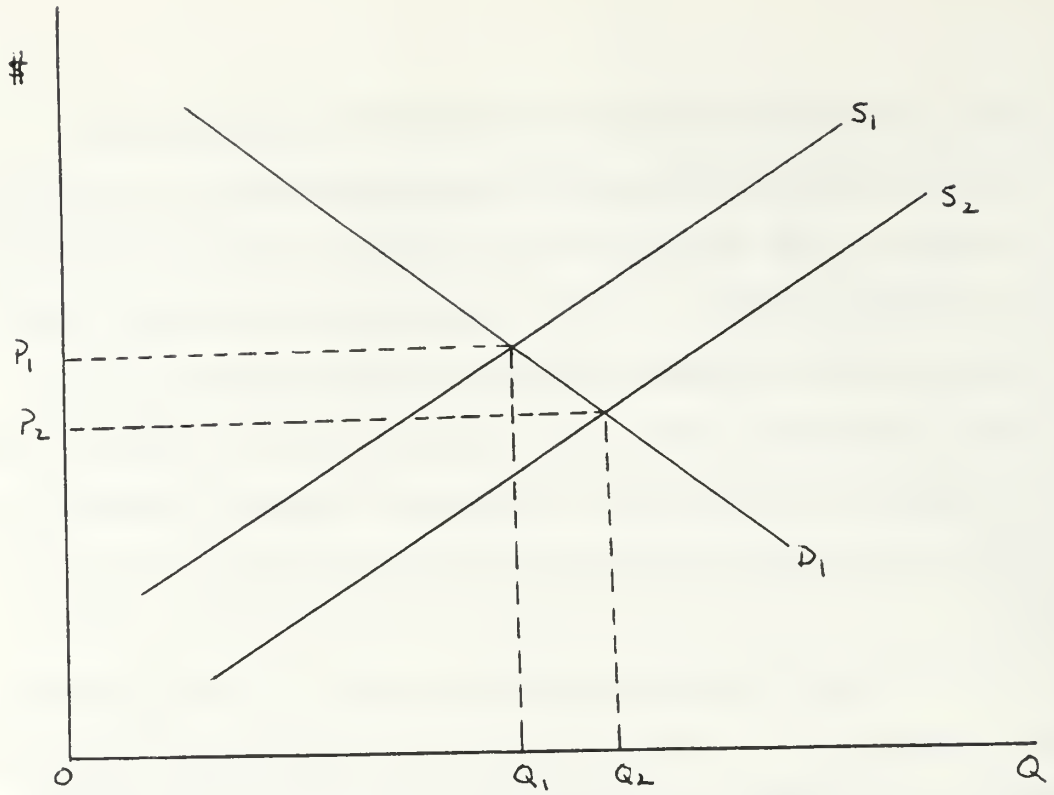

Figure 1. Equilibrium Price

functions of market supply and demand. Those producers who cannot produce at the market price are forced to leave the market. As the aggregate quantity available on the market becomes smaller, buyers will then be willing to pay more for the smaller quantity that is now available. A new market price is again reestablished at a higher price and lower quantity. This cycle repeats itself continuously, as the market seeks equilibrium price and quantity.

In a perfectly competitive market, a fair price is therefore determined by the market forces of supply and demand. However a word of caution is necessary. There are no perfectly competitive markets in our world. There are instead forces that act to interrupt the carefully

orchestrated forces of supply and demand from determining an equilibrium price. There are Government regulatory agencies that determine what the market price will be (e.g. Public Utility Commissions). There are taxes imposed on various goods and services in support of socioeconomic and political goals that distort the market price. There are laws that restrict the behavior of individuals and firms in the market (e.g., banking laws).

Although there are many forces that intervene in our markets to render them less than perfectly competitive, there are conditions under which we can assume that the forces of supply and demand are present in sufficient strength to be effective. This condition is referred to as effective competition. The ASPM lists the following as conditions necessary for effective competition. [Ref. 1:p. 2-5]

The ASPM lists the following as conditions necessary for effective competition. [Ref. 1:p. 2-5]

1. At least two offers,
2. That can satisfy the government requirement,
3. Independently contend for a contract to be awarded to the offeror that submits the lowest evaluated price,
4. By submitting priced offers responsive to the stated requirements of the solicitation.

If the contracting officer can assure himself that competition has been effective, by meeting the above conditions, he can assume that the forces of supply and

demand will determine a price that is fair to both buyer and seller. He can also assume that the price will be reasonable to the seller, as those sellers who cannot successfully compete will be free to leave the market. The lowest price offered, by a responsive and responsible offeror, will of course also be reasonable to the buyer.

Therefore, when competition is effective, price analysis alone is sufficient to determine a fair and reasonable price. However, let us now address the situation when competition is not effective. In this situation, a case in which the Government contracting officer will find himself more often than not, there are conditions that prevent the market from determining a fair and reasonable price.

The market may consist of only one supplier, a monopolist. In this situation, the monopolist sets prices, rather than taking the market prices. This price will undoubtedly be higher than the price the effectively competitive market would ask. Or the market may consist of a small number of suppliers in a market effectively closed to the entry of other competitors. In this situation, the oligopoly, the relatively few, and protected from price competition, set the market price by non-price competition (e.g. advertising, quality) or even by collusion. By choosing to not compete on the basis of price, the oligopolist's price will again be higher than the price the competitive market would ask.

On the buyer side of the market, there may be equally powerful forces restricting competition. The buyer may find himself as the only user of a commodity. It is in such a situation, a monopsony, that the Government often finds itself in the procurement of weapon systems.

In a market in which competition is not effective, price analysis alone will not be sufficient to determine a fair and reasonable price. The contracting officer must look beyond the prices offered, to the costs of production.

B. COST ANALYSIS

The FAR requires that contractors submit cost or pricing data for the following contracts. [Ref. 3:pp. 15-27]

1. Negotiated contracts (except for unpriced actions such as letter contracts) expected to exceed $100,000.
2. The modification of any sealed bid or negotiated contract when the modification involves a price adjustment expected to exceed $100,000.
3. The award of a subcontract at any tier, if the contractor and each higher tier subcontractor have been required to furnish certified cost or pricing data, when the subcontract is expected to exceed $100,000.
4. The modification of any subcontract covered by part 3 above, when the price adjustment is expected to exceed $100,000.

The exceptions to this requirement for submittal of cost or pricing data are when the contracting officer determines that prices are: [Ref. 3:pp. 15-27]

1. Based on adequate price competition, or

2. Based on established catalog or market prices of commercial items sold in substantial quantities to the general public, or

3. Set by law or regulation.

The FAR goes on to define cost analysis as: [Ref. 3:pp. 15-25]

> The review and evaluation of the separate cost elements and proposed profit of (a) an offeror's or contractor's cost or pricing data, and (b) the judgmental factors applied in projecting from the data to the estimated costs, in order to form an opinion on the degree to which the proposed costs represent what the contract should cost, assuming reasonable economy and efficiency.

Cost analysis is therefore a technique to be used to evaluate a seller's actual or proposed cost data. The purpose of analyzing cost data is to prepare a negotiating position which the buyer can use to reach agreement with a contractor.

If the contracting officer can assure himself that there has been effective competition, in either a sealed bid or competitive proposal, then he may satisfy himself through the use of price analysis that the lowest price offered will represent a fair and reasonable price. However, if there has not been effective competition in a negotiated contract, modification, or subcontract (of which each higher tier was required to submit cost or pricing data) in excess of $100,000, then cost analysis, in addition to price analysis must be used to determine what is a fair and reasonable price. Exceptions to this are noted above.

How then is cost analysis to be conducted? The FAR prescribes the following techniques and procedures. [Ref. 3:pp. 15-35 to 15-36]

1. Verification of cost or pricing data and evaluation of cost elements, including--

    a. The necessity for and reasonableness of proposed costs, including allowances for contingencies.

    b. Projection of the offeror's cost trends, on the basis of current and historical cost or pricing data.

    c. A technical appraisal of the estimated labor, material, tooling, and facilities requirements and of the reasonableness of scrap and spoilage factors; and

    d. The application of audited or negotiated indirect cost rates, labor rates, and cost of money or other factors.

2. Evaluating the effect of the offeror's current practices on future costs. In conducting this evaluation, the contracting officer shall ensure that the effects of inefficient or uneconomical past practices are not projected into the future. In pricing production of recently developed, complex equipment, the contracting officer should make a trend analysis of basic labor and material even in periods of relative price stability.

3. Comparison of costs proposed by the offeror for individual cost elements with--

    a. Actual costs previously incurred by the same offeror;

    b. Previous cost estimates from the offeror or from other offerors for the same or similar items;

    c. Other cost estimates received in response to the Government's request;

    d. Independent Government Cost Estimates (IGCE) by technical personnel; and

    e. Forecasts or planned expenditures.

4. Verification that the offeror's cost submissions are in accordance with the contract cost principles and procedures in FAR part 31 and, when applicable, the requirements and procedures in FAR part 30, Cost Accounting Standards (CAS).

5. Review to determine whether any cost or pricing data necessary to make the contractor's proposal accurate, complete, and current have not been submitted or identified in writing by the contractor. If there are such data, the contracting officer should attempt to obtain them and negotiate, using them or making satisfactory allowance for the incomplete data.

6. Analysis of the results of any make-or-buy program reviews, in evaluating subcontract costs.

A significant difference between cost analysis and price analysis is the absence of the market forces of supply and demand in sufficient strength, that are used during price analysis, to determine a fair and reasonable price. Cost analysis, in effect, substitutes the subjective interpretation of the contracting officer, or his assistants, in determining the reasonableness and fairness of contractor proposed costs. Without effective competition, the contracting officer must assess the proposed costs and answer the question, "Are these the costs to produce the required goods and services, if the contractor works with reasonable economy and efficiency."

In answering this question, the contracting officer must center his evaluation around the contractor's cost estimating and accounting system. Both must conform to the requirements of the Cost Accounting Standards [CAS] and the Cost Principles of the FAR. From this point the contracting officer must then proceed to the assumptions the contractor

has made in preparing his estimate. The contracting officer can question the validity of these assumptions based upon comparisons made with costs received from other offerors, or with costs of similar items. Comparison may also be made with cost estimates. Finally the contracting officer will examine the proposed costs from a technical perspective. This examination should determine the effectiveness and efficiency of the means of production, as well as the necessity for costs based upon the means of production.

In conducting the cost analysis, the contracting officer is forced to make subjective decisions. There is no universally accepted quantitative method, as in price analysis, to indicate with a reasonable amount of certainty what is a fair and reasonable price. The conditions of effective competition are not present, and therefore the lowest price cannot be assumed to be the most reasonable. In fact, there will certainly be occasions when the lowest price is not reasonable. When there is effective competition, we assume that contractors are free to move into and out of a market, or to at least have the freedom to choose not to compete. However, when contractors do not have this freedom of movement or choice, they may be forced to propose a price below the actual costs of production in order to maintain market share.

The difficulties inherent in the subjective nature of cost analysis have laid the foundations for additional

analysis that will better indicate when a contractor is not producing with reasonable efficiency. One such analysis is should cost.

C. SHOULD COST ANALYSIS

Although should cost analysis actually had it's origin in the private sector, it was adopted by the Department of Defense as a panacea to cure what was felt to be unreasonably high cost proposals. [Ref. 5:pp. 26-28] Its first application was by Mr. Gordon Rule, who, as Director of the Procurement Control Clearance Division at the Naval Material Command, created a special negotiating team to review production of 2,053 TF 30 engines for the F-111 aircraft by Pratt and Whitney (P&W) in late 1967.

The goal of this special team was ultimately expanded to obtain a binding agreement with P&W to make certain changes in their practices and procedures, and to obtain certain improvements and innovations that would bring about economies and efficiencies for future requirements. This special negotiation team remained in the P&W plant for three months and utilized approximately 50 people to conduct the review. The team was comprised of personnel from the Navy, Air Force, Navy Plant Representative Office (NAVPRO),Defense Contract Audit Agency (DCAA), and P&W. Each member was highly skilled in one or more areas of management and/or production control. Areas of the P&W operation that were targeted for review included: [Ref. 5:pp. 27-28]

Labor Standards	Manufacturing and General Overhead
Allowances	Standard Material
Plant Capacity	Material Variations
Machine Utilization	Vendor Tooling
Labor Cost	Make or Buy
Variations	Purchasing

The result of this intensive effort, which took eleven months to complete, was a negotiated contract with P&W that saved an estimated $100 million. It should be noted that P&W was at the time a sole source for this contract. Because of the interdependencies of this relationship, P&W was probably as eager as DOD to reach an agreement.

From this auspicious beginning, the prominence of should cost analysis as a technique to be used in determining what a contractor's production costs should be, if he performs with reasonable economy and efficiency, has grown. In particular, the publicized procurement abuses associated with the Reagan Administration's defense buildup of the early 1980's resulted in Congressional action mandating the use of should cost analysis.

Several amendments to the 1986 DOD Authorization Act, included in Title IX Procurement Policy Reform and other Procurement matters, directed the Secretary of Defense to incorporate should cost analysis into DOD procurements. Specifically, the Congress directed the Secretary to report the programs marked for should cost analysis to Congress,

submit a list of those programs planned for should cost analysis, and submit a list of those major acquisitions that are not planned for should cost analysis with justification why those acquisitions are not planned to receive should cost analysis. [Ref. 5:p. 17]

Should cost analysis has effectively been forced upon DOD as a technique to be used on all major DOD contractors. It is an extensive effort, in terms of both time and personnel, to actually go inside a contractor's plant and identify inefficiencies to the contractor. The return on this substantial investment is the reduced costs that can be used to negotiate a lower contract price.

Cost savings of 7% to 15% have been reported with use of should cost analysis [Ref. 5:pp.28-29]. However, because of its high investment in time and personnel, the FAR restricts the use of should cost analysis to acquisitions where; [Ref. 3:pp. 15-39]

1. Some initial production has already taken place.
2. The contract will be awarded on a sole source basis.
3. There are future year production requirements for substantial quantities of like items.
4. The items being acquired have a history of increasing costs.
5. The work is sufficiently defined to permit an effective analysis and major changes are unlikely.
6. Sufficient time is available to plan and conduct the should cost analysis adequately.

7. Personnel with the required skills are available or can be assigned for the duration of the should cost analysis.

Should cost analysis is an attempt to compensate for the weakness inherent in the subjective nature of traditional cost analysis. Because traditional cost analysis methods do not guarantee, with a comfortable degree of confidence, a fair and reasonable price, additional methods are warranted. However, even with a more rigorous method, such as should cost, there are substantial restrictions placed upon its use, as noted above.

D. SUMMARY

Thus far, this research has examined the regulatory requirements for price and cost analysis. Upon further examination, it was shown that there is a firm economic basis supporting price analysis. Namely, in the presence of effective competition, the market forces will act to ensure that the most efficient producer may submit the lowest bid, or offer, if he is so inclined. The lowest bid or offer will therefore represent the fairest and most reasonable price to both buyer and seller.

Cost analysis, on the other hand, is subject to much more subjective interpretation and conclusions. Because competition is not effective, or suspected of not being effective, the market forces of supply and demand cannot be relied upon by the contracting officer to determine a fair and reasonable price. The contracting officer must subject

the contractor's estimates, and estimating and accounting systems to his review. He must determine if the contractor's proposal reflects the efforts of someone working with reasonable efficiency and economy.

Lastly, we examined should cost analysis. Should cost analysis is a cost analysis technique that has been developed in more recent years. It is a technique that is to be used in restricted circumstances where the Government suspects that substantial cost savings could be gained through improvements in contractor efficiency and economy. The Government investment in the should cost analysis itself, however, is substantial. Candidates for should cost analysis must therefore be carefully chosen, as the danger exists of the costs of the study being more expensive than the potential benefits. The regulatory restrictions on the use of should cost analysis reflect this conservatism.

Cost analysis is an inherently weak technique as it depends upon the subjective interpretation of those doing the analysis. As long as this inherent weakness remains, more rigorous analysis, such as that provided by should cost, will be required. However should cost is not the panacea that its proponents claim it to be.

Cost analysis, as a method of contract proposal evaluation, could stand to be strengthened. However, in order to understand more fully those areas where improvement can be made, the relationship of cost analysis to cost

estimating and the source selection process must first be examined.

III. SOURCE SELECTION

A. COST ESTIMATING VS COST ANALYSIS

This chapter, will turn attention to the source selection process. It is during the source selection process that the results of price and cost analysis are used to help determine a contract award that will represent the greatest value to the Government. First, before proceeding, the distinction between cost estimating and cost analysis must be made clear.

Cost estimating is a process done by both the buyer and the seller. The seller must do cost estimating for the obvious reason that it is required in order to submit an offer to the Government. PL-87-653, The Truth in Negotiations Act requires full disclosure of cost or pricing data for all contracts in excess of $100,000 (exceptions to this requirement were noted in Chapter II). This includes full disclosure of the estimating methods used by the offeror in compiling his proposal. [Ref. 7:p. 265]

But, depending upon the dollar value of the procurement, the Government will also prepare its own cost estimate of the procurement. For those procurements designated as major weapon systems, and those to be managed as major weapon systems, DOD will prepare an Independent Government Cost Estimate (IGCE).

In addition to the need to prepare an estimate for budgetary reasons, the Government will also prepare an estimate to be used as a yardstick in analyzing contract proposals. As previously discussed, when effective competition is present, price analysis alone is sufficient to determine a fair and reasonable price. However, in the absence of effective competition, cost analysis of the individual cost elements of each proposal must be undertaken. In both cases the IGCE can be used to evaluate the bottom line and individual cost elements. (It is of particular importance if the proposal is from a sole source, as the IGCE may provide the only means of comparison with a proposal's price and cost elements)

Cost analysis, however, is a process done only by the buyer. It is a process that proceeds from the time the offeror's proposal is received by the Government. Nor can it proceed until such time as the offeror's proposal is received. Part of the cost analysis may include, however, an IGCE. Thus, in this regard the Government's cost estimating process may be considered a subset of cost analysis.

Cost estimating and cost analysis are therefore two very closely related processes. In a sense, they are mirror images of each other. It should not be surprising to find that a very good cost estimator will also make a very good cost analyst.

Cost analysis is, however, dependent upon the cost estimate. Cost analysis cannot be done in a vacuum. Although this at first may seem like a truism, the significance of this point should not be overlooked. Because cost analysis depends upon the cost estimate, this in effect means that the contractor can indirectly influence the thrust of the subsequent cost analysis.

To illustrate how this can be done, consider the case of a DOD procurement of a weapon system during the production and deployment phase of the weapon system acquisition cycle. Potential offerors will possess superior knowledge of the market composition and competitor's prices. If in fact the competition is effective, then the respective pricing strategies of offerors will be controlled in effect by the marketplace forces of supply and demand. In order to have a reasonable chance of winning the contract, a contractor can not offer a price too far above his competitors. If he does, he will effectively price himself out of the market. The lowest responsive and responsible bidder could win the competition.

On the other hand, more likely than not there will be competition, but the competition will not be deemed effective. This will occur if, either the proposed prices are so close together that they cannot be differentiated, or price directed sourcing is inappropriate (e.g. during an educational buy to establish a second source). In this case

the pricing strategy will be much more flexible. An offeror's price may now range as high as his estimating system may deem necessary, and as low as his competitor's proposed estimate.

In the first situation, where competition was effective, the price offered was in effect constrained by the competition. In the second case, where competition was not effective, the price offered is considered not to be necessarily indicative of the offeror's cost to produce. Although price must be considered, it is subordinate to the analysis of the reasonableness of the cost elements.

When competition is not effective, or price directed sourcing is inappropriate, source selection must be made on the basis of other factors, in addition to price. The reasonableness of the costs proposed is one of these factors. Cost analysis will, as indicated in Chapter 1, strive to identify what a reasonable and fair price should be through the examination of individual cost elements. However, as long as the offeror can justify all, or as many as possible of his estimated costs, it is unlikely that cost analysis will result in anything more than a marginal decrease in the offeror's original proposal. In fact, in such a situation, it would not be unthinkable that the IGCE would be re-evaluated upward to reflect the higher costs submitted in the proposals. Because the Government has been forced to subjectively evaluate the proposed costs, the

contractor has much more discretion in deciding proposed costs, and ultimately price. The offeror thus indirectly controls the results of the Government cost analysis, to a much greater extent than when the Government uses price analysis to determine a fair and reasonable price.

To summarize, there are two alternative routes that a contractor's proposal may take. If there is effective competition present, the fairness and reasonableness of his proposal will be determined through price analysis of the proposals. Price analysis will depend upon the market forces of supply and demand to indicate which proposal represents a fair and reasonable price. In the absence of effective competition, the contractor will have much more flexibility in preparing his contract proposal. Because the Government will be forced to determine the reasonableness of the offered price through the use of cost analysis, the contractor's proposed price will rest upon the strength of his estimating system. He may therefore choose from among several different pricing strategies. The contractor in effect controls the thrust of the cost analysis.

With this in mind, let us now turn our attention to how the Government, as a buyer, utilizes the information from contract evaluation to make contract award during the source selection process.

B. THE SOURCE SELECTION PROCESS

If, as we saw in Chapter I, the objective of cost(and price analysis) is to determine what is a fair and reasonable price the Government should pay for required goods and services, then the purpose of cost analysis is to develop a negotiating position. As we shall see, DOD must develop a negotiating position for each offeror that qualifies to enter discussions. For it is during negotiations that the buyer and seller will reach mutual agreement on a price.

The easiest source selection method to understand is the sealed bid. The sealed bid is one of two authorized competitive contracting methods established by the Competition in Contracting Act of 1984 (CICA). (The other method being Competitive Proposals.) [Ref. 7:p. 126] In order to use the sealed bid procedure, three requirements must be met [Ref. 7:p. 126].

1. Award of the contract must be on the basis that all bidders have an equal chance to receive the contract.
2. Selection of the winning bidder must be based upon the lowest bid received (from a responsive and responsible bidder who is capable of performing the undertaking).
3. Selection of the winning contractor must be through a public procedure in which a public record of the decision is made available to any interested party.

If the contracting officer can then subsequently assure himself that competition has been effective, price analysis is the appropriate means of determining source selection.

The lowest bidder will represent a fair and reasonable price.

Source selection for the second method of competitive contracting prescribed by CICA is somewhat more complicated. Competitive proposals are first of all used when DOD anticipates that discussions will be necessary between buyer and seller. Discussions may be necessary, and sealed bidding inappropriate for a variety of reasons. Among these are.

1. The inability of DOD to describe the required goods or services in sufficient detail such that every bidder will have an equal chance of contract award.
2. When price alone is not the most important basis of contract award.
3. When competition is deemed inadequate to support price directed sourcing.

When these conditions exist, the FAR requires the contracting officer to follow the three step source selection procedure. The three step procedure is as follows [Ref. 3:pp. 15-19 to 15-23].

1. Issuance of the Government's solicitation in a Request For Proposals (RFP).
2. Receipt and evaluation of proposals in accordance with previously defined and approved evaluation criteria.
3. Contract award.

Before expanding on these three steps, several points deserve clarification. Firstly, the Government must always reserve the right to make contract award without discussions with any of the offerors. This caveat is warranted as

competition may be deemed effective, thus permitting contract award on the basis of price alone. However, once discussions have been held with one offeror, they must be held with all offerors.

Secondly, where competition is deemed not to be effective, contract award will still be made on the basis of at least price and other price related factors. The Government may select in this case the source whose proposal offers the greatest value to the Government in terms of performance, cost, schedule, logistics support and other factors. The choice of the proposal that represents the greatest value, implies that the Government is capable of making tradeoffs among these factors to yield the most advantageous proposal. However, price or cost to the Government shall be included as an evaluation factor in every source selection.

In now turning to discuss the three step source selection procedure in more detail, the first item to define is the source selection criteria. The FAR lists the following, in addition to price, as evaluation factors that may apply to a particular acquisition: cost realism, technical excellence, management capability, personnel qualifications, experience, past performance, and schedule [Ref. 3:pp. 15-19]. However, the RFP must indicate the evaluation criteria that will be used and their relative importance. In addition, the source selection plan, listing

the source selection criteria and their relative importance, must be completed prior to issuance of the RFP.

In discussing step two of the process, the Department of the Navy Supplemental Regulations (NARSUP) to the FAR will be used for examples. The NARSUP requires that, prior to opening negotiations with any of the offerors, a summary comparison of the appropriate cost elements will be prepared [Ref. 8:p. 1.6-24]. Table I illustrates this comparison for sample typical cost elements.

This summary comparison must be made for each offeror in the competitive range. The determination of the competitive range is made through a process in which offerors are sorted into three categories.

1. Those offers which have a reasonable chance of being awarded the contract.
2. Those offers potentially capable of being awarded the contract, yet discussions are required to clarify and discern uncertainties and ambiguities.
3. Those offers clearly not acceptable.

The key decision is whether the offeror, on the basis of price or cost, has a reasonable chance of being awarded the contract [Ref. 7:p. 266]. If so, then they will be included in the competitive range and will be included in all further discussions. In addition, those who fall into the second category will be included in all subsequent discussions until such time as they may be disqualified from further discussions. Those in the third category must be

TABLE I

SUMMARY COST ELEMENT COMPARISON

	Contractor's Proposal	DCAA Audit Report	Field Pricing Report	Prenegotiation Position
Direct Material				
Purchased Parts				
Subcontracted				
Raw Material				
Material O/H				
Direct Eng. Labor				
Eng. Overhead				
Direct Mfg. Labor				
Mfg. Overhead				
Other Direct Costs				
G&A Overhead				
Profit or Fee				

notified immediately that they are not eligible to receive the award.

Through comparison of the contractor's proposal with the Defense Contract Audit Agency's audit report, and with the technical report included in the field pricing report, and based upon cost analysis of the proposal's cost elements, a prenegotiating position will be developed for each element of each proposal.

The prenegotiating position is that which the negotiator will carry into his negotiations with respective offerors. The contracting officer negotiates a separate agreement with each offeror.

The final step of the process, contract award, must be made on the basis of the previously established evaluation criteria. Several methods are used; however, the three most prominent are: adjective ranking, numerical point scoring system, and the composite method [Ref. 9:pp. 7-9].

Adjective scoring involves the application of adjective labels, such as superior, good, average, etc., to each evaluation factor, including cost, for each proposal. It is important that the adjectives applied to each proposal factor are kept confidential to prevent them from influencing the choice of adjectives to be applied to the other proposal factors. From this a summary overall rating is assigned to each proposal. After the overall adjective ratings are completed, proposals are ranked in comparison with each other.

The numerical point scoring system is similar to the adjective ranking system, except that numerical values, typically from 0-100, are applied to all evaluation factors instead of adjectives. Proposals are then similarly ranked according to their numerical score.

Finally, the composite method, is, as its name implies, a combination of adjective labels and numerical scores. The

numerical scores are assigned as a preliminary assessment or guide in selecting the most appropriate adjective ratings. Adjective ratings are then applied based upon the numerical scores received. Proposals are then ranked against each other as in the adjective method. In all three methods different weights may be assigned to each evaluation criterion according to the importance placed upon that criterion for the instant contract. The weights must be decided, however, prior to scoring or rating of the proposals.

DOD has developed a four step source selection procedure, mainly used in research and development contracts. [Ref. 10:p. 15.6-1] The primary difference between this procedure and the three step procedure previously discussed, is that cost and technical proposals are received in a two phased process and after source selection has been made, final negotiations are held between the DOD and the contractor to determine the final contract price. The evaluation procedures are essentially the same.

The significance of the source selection process, for the purposes of this thesis, is that the process may not necessarily, in fact, result in the choice of the best value to the Government. The process assumes that proposals can be scored, or rated in varying degrees of accuracy, on the basis of predetermined evaluation criteria. This, itself, assumes that all proposals will differentiate themselves

according to these evaluation criteria. But what happens if they do not differ substantially with respect to many of the evaluation criteria?

The results can be seen in the following example. Assume that two contractors are competing for a competitive proposal type contract. Their proposals are evaluated and found to be equally acceptable with the exception of cost. In this situation, the bottom line price will become the discriminating factor, as the contracting officer will negotiate the lowest price possible with each competitor. While this may at face value appear not to present any problems, upon closer examination it may present significant difficulties.

If, in fact, the offeror with the lowest price has intentionally underbid the contract in hopes of winning the contract, on the basis of price alone, then the Government can expect to see change proposals subsequent to contract award. The contractor's strategy in this case may have been to underbid his competition and then increase the contract price through the negotiation of change proposals. In the long run this may increase the cost of the contract substantially to the Government.

Has the award of the contract in this case been to the proposal that represents the best value to the Government? Clearly, the Government assumed that the source selection process had resulted in award to the best value. However,

because price alone may not represent the best value, the Government may be deceived in making award on the basis of price alone. The source selection process thus may not offer the Government the best value. Rather it may in some circumstances encourage the contractor to underbid the contract in order to win the competition. Further refinement of the process is necessary.

C. COST REALISM

Cost realism is a contract evaluation criterion, which in a manner similar to the way in which should cost analysis has attempted to compensate for the inadequacies of cost analysis, has been used to compensate for the above identified weaknesses of the source selection process. The requirement that contractor proposal costs reflect realistic estimates of the actual work to be done can be found across the Services.

In the Department of the Army, AMC Regulation 715-1 defines cost realism as,

> The employment of preplanned methods to determine the probable total cost for a procurement at completion; cost realism involves a comprehensive analysis to develop and establish the probable overall cost of performance when related to the required technical scope of the work. [Ref. 6:p. 3-2]

Department of the Air Force Regulation 70-15 states,

> Continued effort must be exerted to achieve greater cost realism in proposals for major development programs. A proposal may be penalized...to the degree that the proposed cost/price is unrealistically low. [Ref. 6:p. 3-2]

Within the Department of the Navy, cost realism has taken on a quantitative aspect. At what was formally known as the Naval Electronics Systems Command [NAVELEX], and is now known as the Space and Naval Warfare Systems Command [SPAWAR], Cost Realism is directly used as a source selection criterion.

As one of several source selection criteria, SPAWAR will give rather explicit guidance to offerors on the importance placed upon the cost realism of the offer.

> Cost will be evaluated to determine whether the estimate is reasonable and realistic for the technical/management approach offered, as well as to determine the offeror's practical understanding of the effort. The government will establish realistic contract cost for the offeror's proposal based upon the offeror's design and offeror's historical cost as demonstrated by the offeror. The cost evaluation will assess the following elements: cost realism and realistic estimated (absolute) cost.
>
> Cost realism factors to be evaluated under cost realism include:
>
> 1. To minimize built in cost growth, the government intends to evaluate the realism of the offeror's proposed costs in terms of the offeror's proposed approach. Proposals may be penalized to the degree that the proposed costs are unrealistic. To assist the government's evaluation, offerors are required to furnish the procedures and rationale used in compiling proposed costs. All information such as IR&D effort, etc., which an offeror wants the government to consider under this factor must be disclosed.
> 2. An offeror's proposal is presumed to represent the best efforts to respond to the solicitation. Any inconsistency, whether real or apparent, between promised performance and cost should be explained in the proposal. For example, if the intended use of new and innovative production techniques is the basis for an abnormally low estimate, the nature of these techniques and their impact on cost should be explained; or if a corporate policy decision has been made to absorb a portion of the estimated cost, that should be stated in the proposal. Any significant inconsistency, if unexplained, raises a fundamental issue of the offeror's understanding of the nature and scope of the work required and of the ability

to perform the contract, and may be grounds for rejection of the proposal. The burden of proof as to cost credibility rests with the offeror.

3. A comparison will be made of each offeror's proposed costs with the government developed realistic estimated contract cost for that offeror, to evaluate the offeror's understanding of the resources required to successfully perform the proposed contract. The closer the offeror's proposed cost is to the government developed realistic contract cost, the higher the score.

The scoring system used by SPAWAR to determine cost realism can be illustrated by Figure 2 [Ref. 6:pp. 4-6]

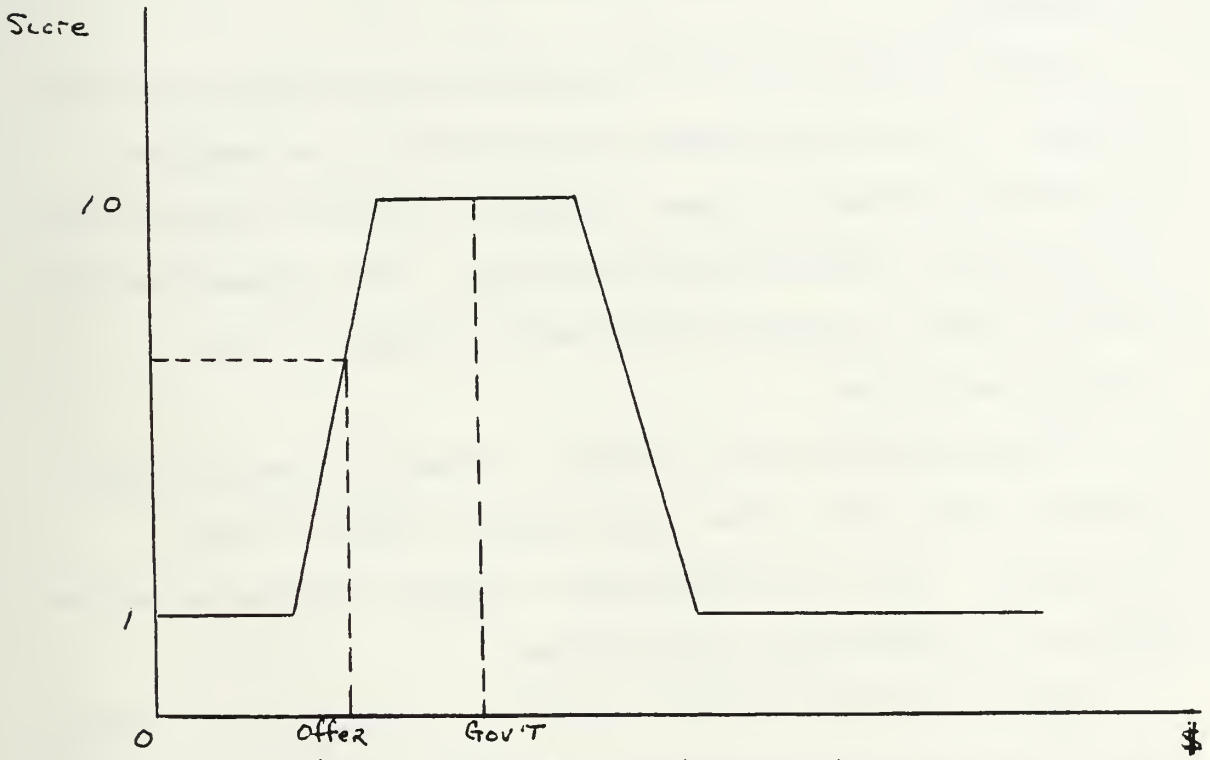

Figure 2. Cost Realism Scoring

The score received by an offer is based on how close the offeror's proposed cost is to the Government's estimate. The score is a maximum of 10 if the proposed cost is sufficiently close to the Government estimate-typically 1.5% to 3.0%. The score is a minimum of 1 if the proposed cost

is sufficiently above or below the Government estimate-typically 15% to 25%. In between, the score can be interpreted from the "Mesa", as shown in Figure 2. [Ref. 6:pp. 4-5 to 4-6]

The score received during this cost realism evaluation will then be used during the source selection process to determine contract award.

D. SUMMARY

In this chapter, we have examined the source selection process. We have seen that the results of the contract evaluation process are used directly in source selection in determining a prenegotiating position. The prenegotiating position must be developed for each proposal in the competitive range.

The source selection process strives to identify that proposal which will offer the greatest value to the Government. This is accomplished through the use of source selection criteria and negotiations.

The prerequisite methods that are used prior to entering source selection are, however, less than perfect. Cost analysis can be indirectly influenced by a contractor's estimating methods and system. During the source selection process itself, the lack of effective competition may result in the selection of a contract winner on the basis of price alone. This may then encourage contractors to attempt "buy ins."

Cost realism is a source selection criterion used to preclude either contractor underbidding or overbidding. However, as we shall see in the next chapter, it also has dangers to avoid in its application.

The next chapter will concentrate on drawing some conclusions as to the effectiveness of the contract evaluation and source selection process based upon our examination of the process thus far.

IV. FINDINGS

A. FAIR AND REASONABLE PRICE VERSUS BEST VALUE

The analysis thus far has shown that there are two methods the Government may use, during the contract evaluation stage of the acquisition process, to determine a fair and reasonable price to pay for required goods and services. These two methods are price analysis and cost analysis.

Price analysis has a firm economic foundation to support itself. It assures the contracting officer that when effective competition is present, the most efficient producer will be able to offer the lowest price, if he is so inclined to do so. The forces of the marketplace thus control the pricing strategy of the competitors to a very great extent. Because of this, the Government, as the buyer, may rest fairly well assured that in choosing the lowest bid in the presence of effective competition, they are receiving a price that is fair and reasonable to both buyer and seller.

The other method considered is cost analysis. Cost analysis is used in the absence of effective competition. Cost analysis consists of various mechanisms that test the reasonableness of the offeror's assumptions and estimating system. Cost analysis strives to assess the validity of the

contractor's proposal by substituting the contracting officer's analysis for the forces of the marketplace.

However, cost analysis is, at best, an imperfect analytical methodology. Assuming that we are analyzing the cost proposals of two or more offerors competing for a DOD production contract, the contracting officer must begin his cost analysis with the system or methods the contractor uses to compile his proposals. The buyer in this situation can be "gamed" by the seller. The seller can rely upon his cost estimating system to inflate costs, if he is so motivated, up to, but probably just below the amount the Government has budgeted for the program. The onus is therefore upon the Government contracting officer to detect and uncover this "padding".

This "padding" can result in either of two different cases. In the first case, that of a cost type contract, the offeror that wins the contract could invest this "padding" in the costs incurred during contract performance. As he is reimbursed for all allocable and allowable costs, this "padding" results in larger revenues under the instant contract, but also more, or better, contract performance to the Government.

In the second case, that of a fixed price type contract, this "padding" could instead result in greater profits for the contract winner. Under a fixed price type contract, the contract price is fixed for the duration of contract

performance. Thus by overestimating costs, and keeping actual incurred costs low, the contractor ensures himself a greater profit.

The competitive proposal contracting arena can be viewed a negative, but perhaps realistic, game of cat and mouse. In this game, the Government contracting officer tries to catch the seller padding his estimates. As one can readily see, success at this game will greatly depend upon the experience and skills of the players.

When the Government can therefore use price analysis, the pricing strategies of offerors are fairly well constrained. However, when the Government is forced to rely upon cost analysis, the offerors control their pricing strategies to a much greater extent.

Should cost analysis is one method that is used to compensate for the deficiencies of cost analysis. Should cost analysis has reportedly resulted in cost savings of anywhere from 7% to 15% [Ref. 5:pp. 28-29]. On the one hand, this validates the argument that traditional cost analysis methods do not necessarily result in fair and reasonable prices. However, it does not mean that should cost analysis has resulted in cost reductions resulting in the lowest possible prices. These indicated cost reductions may be only a portion of the iceberg .

Should cost analysis is a valuable, but expensive tool. Should cost analysis requires the utilization of many highly

skilled specialists for extended periods of time. Past should cost manpower requirements ranged from as few as eight persons to as many as 80 persons. Depending on the depth of the analysis, Government personnel may be at a contractor's facility from a few weeks to several months [Ref. 5:p. 23].

Because of the significant costs incurred by the Government, should cost projects must be carefully chosen. The real possibility exists of the costs outweighing the benefits.

We have also examined the source selection process and the procedures that are used to ascertain the greatest value to the Government. We have seen how this process can lead to underbidding of contracts or "buy ins". Cost realism was subsequently presented as a concept that is used to compensate for the deficiencies of the source selection process.

The source selection process seeks to evaluate contract proposals on a "greatest value" or "best buy" basis [Ref. 8:p. 2]. The process requires the contracting officer to develop a prenegotiating position for each proposal, based upon the results of the previously completed cost analysis, the DCAA Audit Report, and the field pricing report. A negotiated price is then reached with each offeror from which the Government may select the "greatest value". The "greatest value" in this case is that offer which provides

the solicited product or service in the most beneficial combination of performance, schedule, and logistic support, at the lowest overall price to the Government. However, this process also encourages the contractor to "game" the Government. If, as often happens, competitive proposals are evaluated such that they are scored relatively equal on all evaluation criteria, except cost, then price will become the discriminating factor. The lowest price may not, however, in this case represent the greatest value. If an offeror is intentionally underbidding a contract in anticipation of submitting change proposals after contract award, then the ultimate overall cost to the Government could be much greater than that initially accepted by the Government. Contractors may be forced to attempt "buy ins" of this nature in order to maintain their market share in a shrinking market.

To preclude "buy ins," cost realism scoring systems are used to evaluate the basis of proposed costs. There are pitfalls, however, to avoid in applying cost realism scoring systems. The system used by the Space and Naval Warfare Systems Command [SPAWAR], relies upon an independent Government cost estimate. However, this estimate, (like the contractor's proposed estimate) is a random variable. Both estimates, in order to be compared, must be identified by their distributions. The following example illustrates this case [Ref. 11:p. 2].

Consider two competing proposals which differ substantially with respect to the technical and management approach. Proposals costs, the corresponding Government estimates for those proposals and the uncertainty associated with the cost estimates, represented by their probability distributions, are graphically shown in Figure 3.

- Proposal A: This system uses existing technology in which the offeror is the industry leader. Costs are easily related to historical performance. Ca represents a point on the x axis associated with contractor A's cost proposal, and Cg(A) represents a point on the x axis associated with the Government estimate for that proposal.

- Proposal B: This system requires the development of new technology about which there is little historical cost data. CER'S involve large extrapolations. Cb represents a point on the x axis associated with contractor B's cost proposal, and Cg(B) represents a point on the x axis associated with the Government estimate for that proposal.

In both cases the Government estimate for respective proposals, Cg(A) and Cg(B), exceeds the proposal cost by the same amount.

Under the cost realism scoring system both proposals would receive the same score, as they differ from the Government cost estimate by the same amount. However, the probability that contractor A's cost proposal represents the true cost to produce, as estimated by the Government, is less than .01. Contractor B's proposal, on the other hand, is much more realistic, falling well within the left hand tail of the probability distribution.

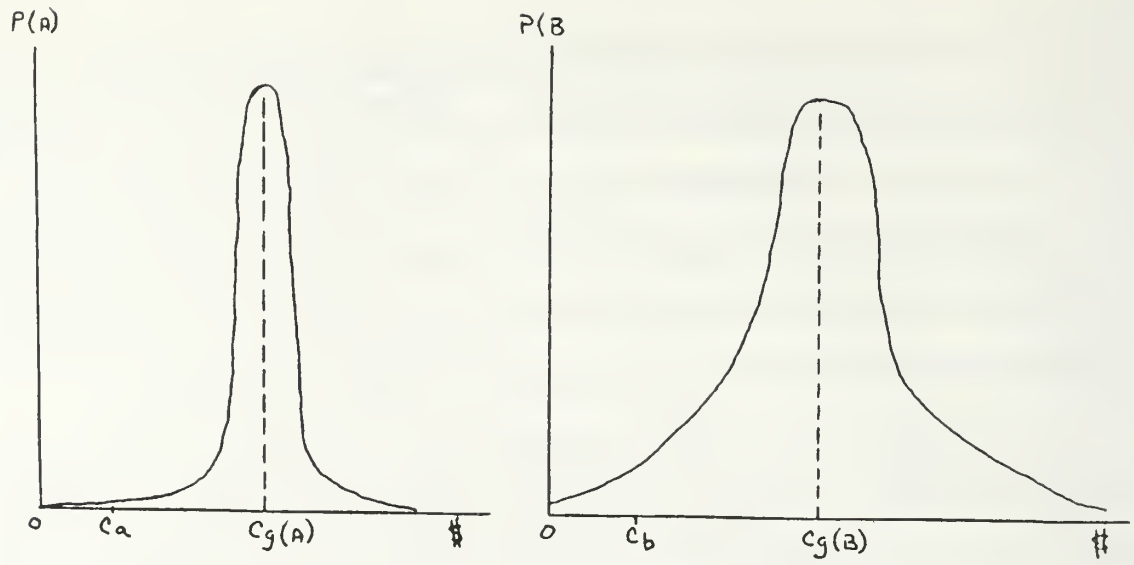

Figure 3. Cost Realism Scoring System

This illustration demonstrates the difficulties associated with the use of scoring systems to determine the realism of contract proposal costs.

Present cost analysis methods, as described by the FAR, do not necessarily result in the choice of a fair and reasonable price. Rather, they permit a offeror the flexibility to liberally estimate costs, if he so desires. Nor does the source selection process necessarily result in contract award for to the "greatest value". The source selection process may, rather, encourage the contractor to attempt a "buy in." Both processes react to contractor estimating and pricing strategies and facilitate "gaming."

B. CONCLUSIONS

1. Price analysis methods are based upon the underlying forces of the marketplace to determine a fair and reasonable price.

2. Cost analysis is a subjective method lacking a firm economic basis, such as that which supports price analysis.

3. Cost analysis does not necessarily result in the choice of a fair and reasonable price that the Government should pay for required goods and services, and may actually encourage the contractor to liberally estimate costs, if he so desires.

4. Should cost analysis is a concept that is used to compensate for the weaknesses of cost analysis.

5. There are benefits that can be derived from should cost analysis, but its costs can also be very substantial.

6. The source selection process may often result in price alone determining contract award. Price alone may not, however, represent the greatest value to the Government.

7. The source selection process contributes to contractor "gaming," through "buy ins."

8. A new approach to cost analysis is required that will strengthen the Government's ability to discern a fair and reasonable price.

9. A new approach to the source selection process is required that will strengthen the Government's ability to choose contract sources representing the greatest value to the Government.

The analysis thus far indicates that our present contract evaluation and source selection tools work fairly well, most of the time. However there are circumstances under which they are subject to failure, resulting in possible financial injury to the Government. The next

chapter, will address the question of how the process can be strengthened.

V. MARGINAL ANALYSIS

A. UTILITY AND VALUE

A logical starting place in strengthening the contract evaluation and source selection process is with the concept of value. The desired result of the process is to determine the greatest value to the Government. However, this is also the source of the process's weakness. The source selection process assumes that tradeoffs can be made between performance, cost, schedule, and logistics support to yield the selection of that proposal that will offer the Government the most advantageous combination at the least cost. However, the scoring systems used in the source selection process do not necessarily assure the choice of the above defined greatest value. Rather, they may force the choice of something less than greatest value. This will occur when all the source selection criteria, except cost, are evaluated so close as to be indistinguishable. Price then becomes the discriminating factor. When a "buyin" is in process, this can result in financial harm to the Government.

In the following analysis, an alternative approach to value is presented based upon a marginal analysis of the direct costs of production. Marginal analysis is central to economics. Economic analysis in general is concerned

with the way in which resources are allocated among alternative uses to satisfy competing demands. Microeconomics concerns itself with the behavior of consumers and firms in pursuit of optimal resource allocation. [Ref. 4:p. 1]

In order to determine how to optimize resource allocation, one must first determine the worth, or value of resources. For many years classical economists had considered the value of a resource to be determined by the cost of its production. During the 1870's this concept underwent radical change. Several European economists, simultaneously and independently, proposed the idea that value was a relative concept. Representative of this notion were the theories of William Jevons in England, Leon Walras in Switzerland, and Carl Menger in Austria. [Ref. 12:p. 204]

This marginalist concept, as it became known, proposed that value derives from utility and scarcity rather than from the costs of production [Ref. 12:p. 222]. The utility derived from a resource is relative to its availability. The larger the supply of a given resource, the less a consumer will be willing to pay for one additional unit of this resource. Thus, the utility of a resource to a user will vary from consumer to consumer depending upon the availability of the resource.

If it was possible to measure the satisfaction a consumer derives from a particular resource, one could measure the total utility associated with certain resources. For example, the utility attached to food could be expressed in units.

Marginal utility, on the other hand, measures the additional satisfaction derived from an additional unit of a resource (when the levels of consumption of all other commodities are held constant). The marginal utility in our food example is derived by taking the difference in total utility as additional pounds of food are added. Table 2 shows this relationship. [Ref. 4:pp. 51-52]

TABLE 2

TOTAL AND MARGINAL UTILITY

Pounds of Food	Total Utility	Marginal Utility
0	0	-
1	4	4
2	9	5
3	13	4
4	16	3
5	18	2

The rational consumer will try to maximize utility. This is a simple concept that means consumers try to derive as much satisfaction as possible from available resources.

However, as we all know, resources have a cost, and most, if not all consumers have limited funds. So consumers must maximize utility within the constraints of their budget. Consumers will therefore attempt to purchase that combination of resources that will yield the greatest total utility.

In order to maximize utility, subject to the constraints of budgets and market prices, the consumer must allocate his funds such that the marginal utility of the last cent spent on good A is equal to the marginal utility of the last cent spent on good B. This requires that differences in expenditures must be balanced by differences in utility, so that if the expenditure on good A is twice as high as on good B, the marginal utility associated with good A will be twice as high as that associated with good B. [Ref. 12:p. 225]

In order to fullfil the above requirement, the rational consumer must allocate his resources such that the,

$$\frac{\text{Marginal Utility of Good A}}{\text{Price of Good A}} = \frac{\text{Marginal Utility of Good B}}{\text{Price of Good B}}$$

This relationship can be expressed mathematically as; [Ref. 4:p. 55]

$$\frac{MU1}{P1} = \frac{MU2}{P2} = \frac{MU3}{P3} = \frac{MUi}{Pi} \qquad [1]$$

where MU1 equals the marginal utility derived from resource 1, and P1 equals the price of resource 1. In order to maximize utility, the consumer must allocate his budget such that the last dollar spent on all resources yields the same proportional marginal utility.

It is this relationship between the marginal utility and prices of resources, as described above, that is defined as an expression of the value of resources. The greatest, or optimal value, will be represented by the most efficient use of resources. Efficiency in this case is represented by consumer allocation of resources, such that the marginal utility derived from the last cent spent on resource A, is equal to the marginal utility derived from the last cent spent on resource B. A lesser value is associated with less efficient use of resources, by the consumer. The optimal value that can be derived from resources is under conditions wherein the relationship of equation [1] holds true. Lesser values are derived from resources when the relationship between resources and prices in equation [1] does not hold true.

The relationship in equation [1] can also be expressed graphically. The rate at which a consumer is willing to substitute one resource for another, and still maintain a

constant level of satisfaction, can be represented by an indifference curve. Anywhere on this indifference curve, the combination, or substitution of marginal amounts of one resource for another, will yield the same amount of satisfaction to the consumer. The indifference curve thus measures the marginal rate of substitution of resources. Figure 4 shows the indifference curve. [Ref. 4:p. 63]

If a line is drawn joining all the points that represent the combinations of goods X and Y that the consumer can afford, given his limited budget, we will have the consumer's budget line. The budget line describes a linear relationship between the goods X

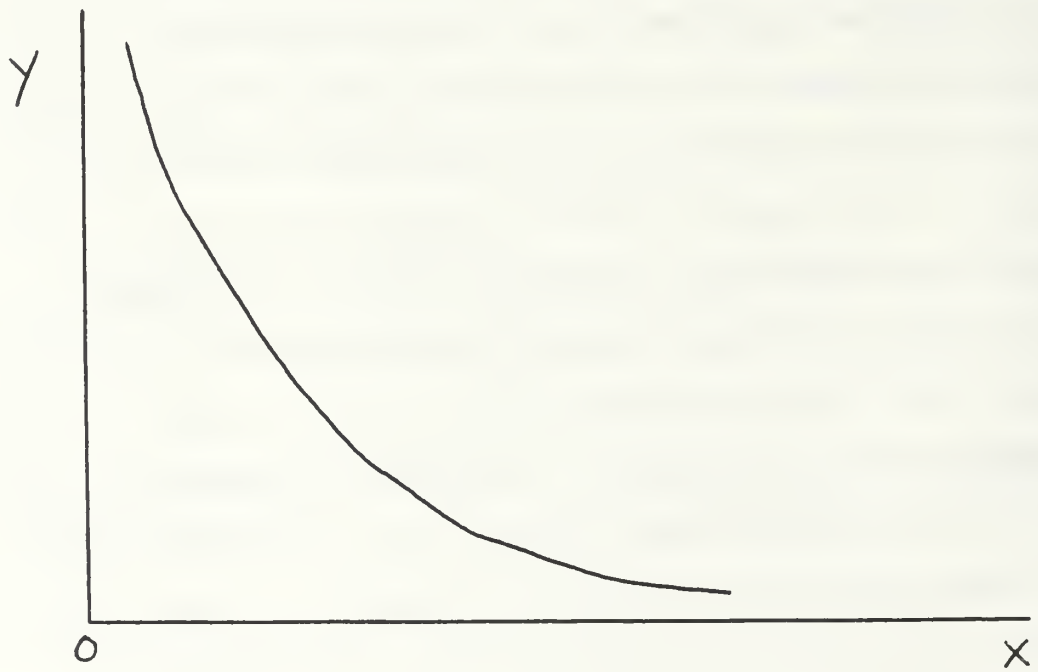

Figure 4. The Marginal Rate of Substitution of Good X for Good Y

and Y, such that constant amounts of goods can be exchanged for one another.

Taking the consumer's budget line and lowering successive indifference curves until such time that the budget line intersects the indifference curve in only one point, we will have maximized the consumer's utility. The indifference curve that touches the budget line at only one point will represent the highest level of satisfaction the consumer can reach. At any indifference curve above this point the indifference curve and the budget line will not intersect, thus representing a combination of resources beyond the consumer's budget. At any indifference curve below this point, the indifference curve and the budget line will intersect at more than one point, representing a less than optimal utilization of resources and a lower level of satisfaction. Figure 5 shows this relationship.

Point C in Figure 5 is that point at which the marginal rate of substitution of good Y for good X is equal to the rate at which the consumer can afford to substitute good X for good Y. At this point of intersection, the slope of the indifference curve is equal to the slope of the budget line, such that,

$$\frac{MUy}{MUx} = \frac{Py}{Px} \qquad [2]$$

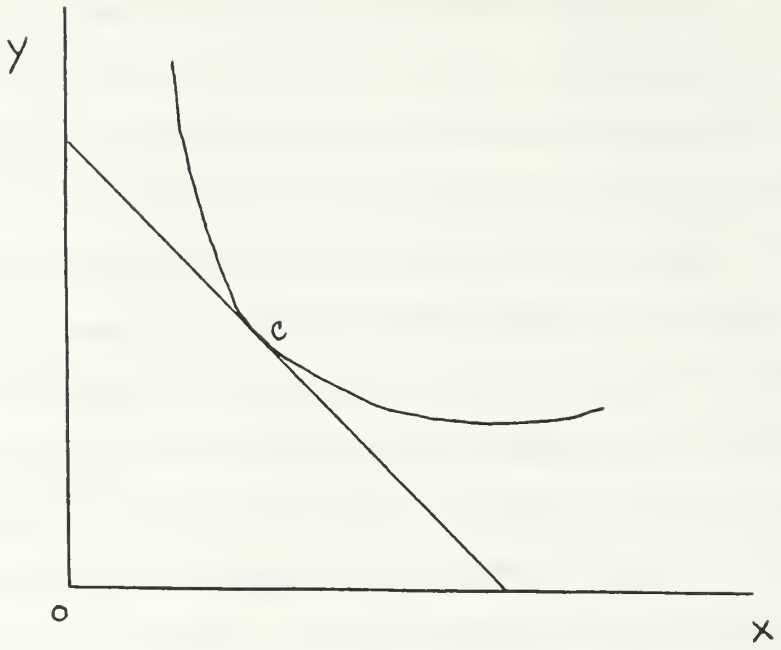

Figure 5. The Consumer's Optimal Use of Resources

Equation [2] can be algebraically rearranged to yield equation [3].

$$\frac{MUy}{Py} = \frac{MUx}{Px} \qquad [3]$$

Equation [3] again describes that condition of greatest value to the consumer.

With this introduction to how an individual can derive the greatest utility and value from the use of resources, let us now turn our attention to how the firm acts to derive value from its use of resources. As compared to the

consumer, a firm can measure the incremental increases in utility as additional amounts of resources are used. Instead of referring to the marginal utility, however, as a measurement of value, we will use the marginal product of a resource.

The marginal product of a resource is the addition to total output due to the addition of the last unit of the input, when the amounts of the other inputs are held constant. [Ref. 4:p. 157] In order to maximize the value of a firm's resources, the firm must derive the same proportion of marginal productivity for each dollar spent on that resource. Thus our condition for optimal value can be stated as,

$$\frac{\text{Marginal Productivity of Good A}}{\text{Price of Good A}} = \frac{\text{Marginal Productivity of Good B}}{\text{Price of Good B}}$$

This can be represented mathematically as,

$$\frac{MPa}{Pa} = \frac{MPb}{Pb} = \frac{MPi}{Pi} \qquad [4]$$

where MPa equals the marginal product of an additional unit of good A and Pa equals the price of good A.

This relationship between a firm's resources can also be expressed graphically. The rate at which a firm can

substitute marginal amounts of one resource for another, and maintain a constant output, is called the marginal rate of technical substitution [Ref. 4:p. 168]. It can be represented by an isoquant. The rate at which the firm can afford to substitute one resource for another within revenue constraints can be represented by an isocost line. [Ref. 4:p. 186] Figure 6 shows an isoquant, A, and an isocost line, B.

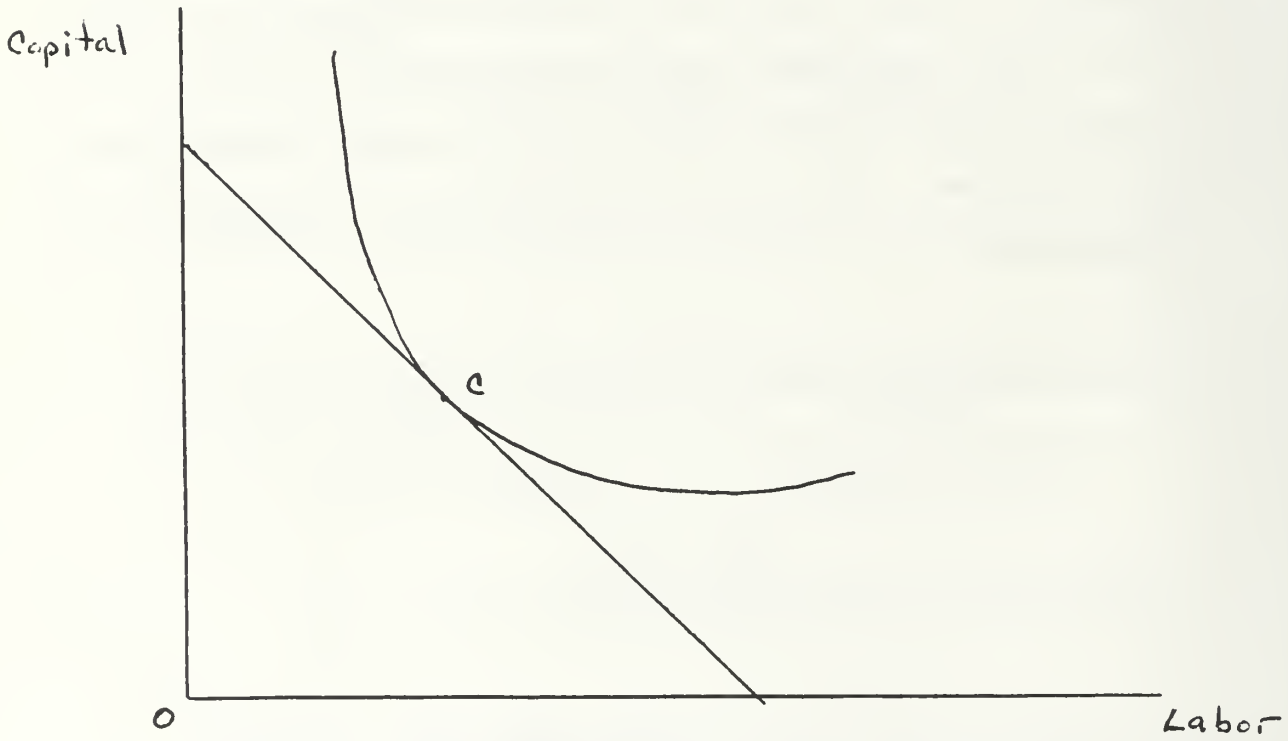

Figure 6. The Firm's Optimal Use of Resources

Point C represents the point at which the slope of the isoquant is equal to the slope of the isocost curve. As this point is also on the highest possible isoquant, it

represents the point at which the firm will derive the greatest value from the two resources, labor and capital.

B. COST AND PRODUCTION FUNCTIONS

A basic assumption of economic analysis is that the firm acts to maximize its profits. [Ref.13:p.1] This concept is appealing both analytically and intuitively. Analytically, this can be expressed as the actions required to maximize revenue and minimize costs. Equation [5] shows this relationship. [Ref. 13:p. 1]

$$\text{Profit} = \text{Max. } R(A1,...An)-C(A1,...An) \qquad [5]$$

Where R = Revenue realized from A actions, and
C = Costs incurred during A actions.

The firm maximizes its profits by producing outputs from various combinations of inputs. The means by which the firm produces can be described as the firm's technology. In examining the firm's technology, two approaches can be taken. One approach is to look at a firm's output in terms of it's technological possibilities. The output is examined in terms of how inputs are utilized. This approach uses production functions to describe this relationship between output and factors of production, or input resources.

The production function describes a particular output based upon possible combinations of resources and the

ability of management to efficiently utilize these resources. Output is therefore determined in part by the availability of resources, and also by the management expertise employed in the production process.

Production functions can be described in terms of constant, decreasing, or increasing returns to scale. With constant returns to scale, a 1% increase in an input gives rise to a similar increase in output. With decreasing returns to scale, output increases by less than the percentage increase in the amount of the resource. Increasing returns to scale result in greater increases in output for a given increase in input resources.

Thus, while it may be possible to specify the quantities of resources to be used during production, the management skills applied in combining these resources may range from poor and ineffective, to outstanding and quite effective. The resultant output possibilities can similarly range from poor to outstanding depending upon the management skills applied. The production function therefore refers to the technological possibilities of the firm.

As opposed to looking at the firm's production function, the second approach to understanding how the firm acts to maximize profit is to look at the firm's cost function. This approach concentrates on the firm's behavior rather than its possibilities. The cost function describes the relationship between inputs, input prices, and outputs.

According to the Duality Theory of Production, the cost function describes all economically relevant information about the technology of the firm.

If C is total cost, then $C = F + V(Q)$, where F is the total fixed costs and V(Q) is the total variable costs, expressed as a function of the total quantity produced, Q. Total cost is therefore dependent upon Q and input prices. As fixed costs are constant in the short run, they will not in the short run affect changes in total cost. Input quantities are determined by the level of output, and are thus determined by Q. The only variables that can determine total cost are therefore input prices and Q, the output quantity. [Ref. 13:p. 35]

By varying the total cost function with respect to the input prices, the technology required to produce various levels of output can be determined. In this fashion, the technology required for a particular cost function can also be determined. [Ref. 13:p. 35]

With use of the Duality Theory of Production, the technology for a given firm can be constructed from its cost function. However, from the buyer's perspective, although we are interested in the seller's technology, in the interests of cost, we are much more interested in how efficiently he uses his technology. The more efficient firm will represent a greater value, as we would expect his costs to be less over time. For this reason, it is more

advantageous for us to further examine the firm's production function.

In theory, a firm's production function describes the most efficient output that can be obtained with an existing state of technology from given quantities of inputs. Only the most efficient production techniques are described by the production function.

The most popular model used in formulating production functions is the Cobb-Douglas production function. The Cobb-Douglas model is of the form,

$$Q = AL^aK^bM^c \qquad [6]$$

where Q is the quantity produced, L is the amount of labor, K is the amount of capital, and M is the amount of raw materials, and A, a, b, and c are parameters to be estimated. [Ref. 4:p. 174]

Admittedly, there are many problems involved in the measurement of production functions. The data collected may not always represent technically efficient combinations of input resources. Another problem is how to measure the diverse nature of capital. Capital is composed of a variety of plant, equipment and facilities. Expressing these in a single point estimate poses unique problems. Theoretically, the use of production functions permits us to make many

assumptions, that may in fact prove difficult to make in actually estimating a production function.

If we assume a Cobb-Douglas production function of the above form, we may derive the marginal product of each factor of production. As the marginal product is equal to the change in output for a given change in input, we simply take partial derivatives of output with respect to each input. This yields the following equations.

$$\frac{\partial Q}{\partial L} = aAL^{a-1}K^{b}M^{c} \qquad [7]$$

$$\frac{\partial Q}{\partial K} = bAL^{a}K^{b-1}M^{c} \qquad [8]$$

$$\frac{\partial Q}{\partial M} = cAL^{a}K^{b}M^{c-1} \qquad [9]$$

Once we have derived the marginal product of each resource, we could then theoretically determine the most efficient mix of resources. As we have seen this occurs when the marginal product of the last dollar spent on one resource is equal to the marginal product of the last dollar spent on the next resource. In the Cobb-Douglas production function this is equal to,

$$\frac{aAL^{a-1}K^{b}M^{c}}{Lp} = \frac{bAL^{a}K^{b-1}M^{c}}{Kp} = \frac{cAL^{a}K^{b}M^{c-1}}{Mp} \qquad [10]$$

Given the production function and the prices of the resources, we could solve for the most efficient mixes of resources.

C. A MARGINAL APPROACH TO COST ANALYSIS

Let us now see how we could use marginal analysis theory to evaluate contract proposal costs. First we shall assume that the production functions of the firms that have submitted proposals have previously been estimated, and they are of the Cobb-Douglas form. As we discussed, there are formidable problems involved in estimating a firm's production function. Nonetheless, we shall proceed for the sake of argument. For purposes of simplicity, we shall also assume that the procurement under consideration requires only one type of direct labor, and two types of direct materials. The production functions of the firms, describing their output in terms of labor, capital, and raw materials, are as follows.

- Firm A

$$Q = L^{\cdot 2}K^{\cdot 4}M^{\cdot 3} \qquad [11]$$

- Firm B

$$Q = L^{.25}K^{.30}M^{.35} \qquad [12]$$

Both firm's proposals are for a production quantity of 5620 units. In order to estimate the values for direct labor and raw materials in equations [11] and [12], the proposals of the firms must first be examined. Both firms' proposals are presented in Table 3.

TABLE 3

FIRM A AND B PROPOSALS

	FIRM A		FIRM B	
Purchased Parts (M)	$20,000		$10,000	
Raw Material (M)	50,000		60,000	
Subtotal	70,000		70,000	
Material overhead	7,000	(10%)	3,500	(5%)
Labor (L)	40,000		30,000	
Labor Overhead	48,000	(120%)	37,500	(125%)
Subtotal	165,000		141,000	
G&A	33,000	(20%)	21,150	(15%)
Subtotal	198,000		162,150	
Profit	19,800	(10%)	16,215	(10%)
Total	217,800		178,365	

Because this procurement is a competitive proposal, and it is over $100,000, cost and pricing data will have been submitted. From the cost or pricing data, we can determine the actual prices and quantities of direct material and labor that both firms have proposed. These are presented in Table 4.

TABLE 4

COST OR PRICING DATA

	FIRM A	FIRM B
Purchased Parts	2,000 Units at $10/ea	2,000 Units at $5/ea
Raw Material	5,000 Units at $10/ea	6,000 Units at $10/ea
Direct Labor	1,000 Hours at $40/Hr.	1,000 Hours at $30/Hr.

Futhermore, our research has shown that this contract will utilize 1% of firm A's plantwide assets of $20M, or $200,000. For firm B, this contract will utilize .57% of his plantwide assets of $50M, or $285,000.

With the information provided in the offerors' proposals and cost and pricing data, the marginal products of direct labor and raw materials, for both firms can be derived. The marginal product of capital can be derived from our previous research, as capital is not presented in the proposals or

cost and pricing data in a form that can be used for this application.

The marginal products of firm A for direct labor, direct material, and capital are,

$$\frac{\partial Q}{\partial L_a} = .2L^{-.8}k^{.4}m^{.3} \quad [13]$$

$$\frac{\partial Q}{\partial M_a} = .3L^{.2}k^{.4}m^{-.7} \quad [14]$$

$$\frac{\partial Q}{\partial K_a} = .4L^{.2}k^{-.6}m^{.3} \quad [15]$$

The marginal products of firm B for direct labor, direct material, and capital are,

$$\frac{\partial Q}{\partial L_b} = .25L^{-.75}k^{.30}m^{.35} \quad [16]$$

$$\frac{\partial Q}{\partial M_b} = .35L^{.25}k^{.30}m^{-.65} \quad [17]$$

$$\frac{\partial Q}{\partial K_b} = .30L^{.25}k^{-.70}m^{.35} \quad [18]$$

For each firm, the most efficient use of resources will occur when the ratio of the marginal products to the price are equal for each resource used. For firm A, this occurs when,

$$\frac{.2L^{-.8}K^{.4}M^{.3}}{Pl} = \frac{.3L^{.2}K^{.4}M^{-.7}}{Pm} = \frac{.4L^{.2}K^{-.6}M^{.3}}{Pk} \qquad [19]$$

For firm B, this equals,

$$\frac{.25LL^{-.75}K^{.30}M^{.35}}{Pl} = \frac{.35L^{.25}K^{.30}M^{-.65}}{Pm} = \frac{.30L^{.25}K^{-.70}M^{.35}}{Pk} \qquad [20]$$

Given that we know the prices of the firm's resources, we could solve the above equations for the most efficient combination of resources required. However, both contractors have proposed the combination of resources they intend to use on this contract. This poses the question, "Which proposal is the most efficient.?"

With the information we have at hand we can determine which firm is using their direct resources most efficiently. If both firms were using their resources at optimal efficiency, the variance of the ratios in equations [19] and [20] would be zero. The variance must be zero because the proportion of marginal productivity to resource price for each resource must be the same. Therefore the firm with

lowest variance will also be the most efficient user of direct resources.

In order to compute the variances, we must substitute in equations [19] and [20], for direct labor and direct material, the quantities of labor, purchased parts, raw materials, capital utilized, and the prices for labor and material. For firm A, we have,

$$\frac{.2(1000)^{-.8}(200,000)^{.4}(7,000)^{.3}}{40}$$

$$= \frac{.3(1000)^{.2}(200,000)^{.4}(5,000)^{-.7}}{10} \qquad [21]$$

$$= \frac{.3(2000)^{.2}(200,000)^{.4}(2,000)^{-.7}}{10}$$

This yields,

$$\frac{1.4961}{40} = \frac{.4057}{10} = \frac{.7705}{10} \qquad [22]$$

Now solving for the variance of these two numbers, using the formula, $s^2 = \sum(X-\bar{X})^2/n-1$, where s^2 is the variance,

$(X-\bar{X})^2$ is the deviation of any value of X from the arithmetic mean, x, $(X-\bar{X})^2$ is the sum of the squared deviations, and n is the number of items in the sample. From this calculation, $s^2 = .0004855$.

If we now do the same calculation for firm B, substituting in equation [20], we have,

$$= \frac{.25(1,000)^{-.75}(285,000)^{.30}(8,000)^{.35}}{30} \quad \frac{.35(1,000)^{.25}(285,000)^{.30}(6,000)^{-.65}}{10} \quad \frac{.35(1,000)^{.25}(285,000)^{.30}(2,000)^{-.65}}{5} \qquad [23]$$

This yields,

$$\frac{1.4082}{30} = \frac{.2983}{10} = \frac{.6136}{5} \qquad [24]$$

Solving for the variance in the same manner as above, $s^2 = .002444$.

Because the variance of firm A is less than the variance of firm B, we may conclude that firm A's utilization of direct resources is more efficient than that of firm B.

This information could then be used in subsequent source selection decisions.

If the source selection warranted concern about a possible "buy in", and all evaluation criteria were in fact evaluated fairly closely, with the exception of cost, then the relative efficiency of the offerors would be critical to source selection. By making the source selection decision now on the basis of efficiency and cost, rather than cost alone, the possibility of the "buy in" strategy succeeding may be averted.

If a "buy in" was a true concern, then efficiency of the offerors would be weighted as an evaluation criterion more heavily than cost. In this case, firm A, rather than firm B would then be the apparent winner. The result of this decision would be twofold. First, the expected change proposals, which would lead to contract cost growth, of the firm attempting the "buy in" would be averted. Secondly, if changes were in fact warranted to the contract, the firm proposing the changes would be the more efficient in terms of usage of direct labor and raw materials. The resultant changes would therefore be expected to cost less.

D. SUMMARY

The marginal analysis illustrated above shows how contract proposals could be evaluated for relative efficiency. For simplicity, only three different direct resources were utilized. In fact, however, a typical

contract proposal will normally comprise many different types and prices of labor, and hundreds, or even thousands of different materials and prices. An analysis of this nature would mandate the use of a computerized application.

In addition, this analysis only concentrates on the efficiency with which direct resources are utilized. It does not address the issue of the efficiency with which indirect materials and labor are utilized. In fact, in our example, firm A utilized direct materials more efficiently than firm B, but their bottom line price was higher than firm B. This was due to their higher overhead costs.

This analysis should be used in conjunction with traditional methods of cost analysis, and include the DCAA audit report (which examines overhead allocations), and the field pricing report. If used as an additional tool of cost analysis, marginal analysis could then aid the contracting officer during negotiations, and ultimately strengthen the source selection process.

Like other cost analysis techniques, marginal analysis should not necessarily be used on all procurements. But, in those procurements where there has been a history of "buy ins" (e.g., commercial overhaul of U.S. Naval ships), marginal analysis may aid in detecting a "buy in."

In this respect, the marginal analysis could be used during negotiations to confront the offeror's position as not reflecting reasonable economy and efficiency. Although

his offer may appear attractive on the basis of price alone, he may find himself excluded from contract award because the Government fears a "buy in." This in itself may be enough to force the offeror attempting the "buy in" to revise his strategy. Hopefully, it would. If it did not, then the results of the marginal analysis could be used as a source selection criterion.

If marginal analysis was to ultimately be used as a source selection criterion, notice of such use must be made in the Request For Proposals (RFP), as well as the relative weight to be accorded to it. This decision will again be based upon the Government's past experience with the respective type of procurement. Its use could be very similar to that of cost realism, whereby sufficient notice is awarded potential offerors that source selection may not be made on the basis of price alone.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The preceding chapter has demonstrated the theoretical application of marginal analysis to the contract evaluation process. The contracting officer could, if he was permitted to do so by the FAR, use this methodology in his determination of a fair and reasonable price. What remains however, is a determination of the conditions under which this type of analysis could be used.

To begin with, it is important to realize that the significance of cost analysis (or price analysis) is that it is used to develop a prenegotiating position. This fact is shrouded in the regulatory language of seeking to determine a fair and reasonable price. The goal of procurement is to secure goods and services at a fair and reasonable price, but this objective is achieved only through negotiations. Negotiations require a carefully developed plan from which the Government can seek agreement with contractors on a contract. The prenegotiating position is the focal point of this plan. It represents the price the Government actually hopes to reach agreement on. It is also what the Government believes to be a fair and reasonable price to both parties. Cost analysis is a means by which the prenegotiating position is determined.

From this point there are two potential difficulties that can arise. First with our present methods of cost analysis. we may actually be encouraging the contractor to inflate his costs. Both the contractor and the Government anticipate a process in which the assumptions and methods supporting the contractor's estimates will be questioned, ultimately resulting in a Government estimate of the cost to produce below that of the contractor's original proposal. Expecting this to occur, the contractor may very well inflate his costs to compensate for the incremental decreases that cost analysis will necessitate.

Methods have been developed to deal with this problem, such as should cost analysis, but their investment costs are high and the possibility of realizing any net benefits must be carefully examined.

The second difficulty encountered is that once negotiations have been completed with all offerors in the competitive range, the source selection process may be forced to use price as the discriminating criterion. This will occur if all offers are evaluated fairly closely on all other criteria. By default then, price will determine contract award. The difficulty with this result is that price alone may not be the best indicator of the best value to the Government. One of our assumptions in entering into negotiations was that they were necessary to determine a fair and reasonable price because competition was not

effective. We thus entered negotiations because we could not determine contract award on the basis of price alone. We now find ourselves subsequently making contract award on the basis of that which we wanted to avoid, price. There is a glaring contradiction here.

Methods have also been developed to deal with this difficulty, such as cost realism. But there are difficulties inherent in the use of cost realism scoring systems.

These two difficulties in the contract evaluation and source selection process become acute if the contractor is attempting a buy in. A buy in, by definition, is an attempt by an offeror to win a contract by offering a price below that of all his competitors and below his own breakeven point. He then attempts to make a profit on the contract by subsequently negotiating changes to the contract after contract award. The term "getting well through changes" summarizes the buy in philosophy.

DOD is very sensitive to buy ins because they ultimately result in cost overruns and delay in scheduled contract completion. Both of these are the makings of political campaigns against the DOD budget.

During a buy in, these two difficulties can combine to severely injure DOD. If, in fact, a contractor is attempting a buy in, then he may very well win the contract if price alone becomes the sole discriminating criterion.

This alone has potentially serious consequences, which will become apparent to DOD as engineering change proposals start to accumulate. However, the injury that has been inflicted will be compounded because DOD may very well not realize that the buy in strategy has been successful.

DOD assumes that during contract evaluation, cost analysis was used to develop a prenegotiating position. Negotiations were then held with all qualified offerors to reach agreement on a price that was fair and reasonable to both parties. It would therefore appear reasonable to assume that the contract winner should be proceeding in good faith in contract performance. The truth of the matter may in fact be, that cost analysis was inadequate in uncovering the contractor's padding of costs. What DOD assumed to be a fair and reasonable price, was actually the buy in strategy. The buy in may therefore work, and DOD may not realize it until it is too late, because cost analysis results were relied upon.

This thesis has proposed that in the absence of effective competition, marginal analysis is a method that could be used during cost analysis. Marginal analysis seeks to determine which contractor is using direct labor and materials most efficiently. Rather than reacting to the gaming strategy of the contractor's assumptions and estimating system, marginal analysis determines the best

value on the basis of the contractor's utilization of resource quantities and prices.

The methods of contract evaluation and source selection prescribed by the FAR may work fairly well, most of the time. But when a buy in is being attempted, these methods are susceptible to failure. If marginal analysis is utilized when a buy in is suspected, in conjunction with prescribed cost analysis methods, a prenegotiating position will still be developed. However, an additional piece of information will be available. The most efficient operating producer will be known, who will in fact represent the greatest value to DOD if all offers are evaluated fairly closely on all source selection criteria. Rather than source selection then being made on the basis of the lowest price, it will be made on the basis of the most efficient offeror.

B. RECOMMENDATIONS

Efficiency of offerors should be used as a source selection criterion when there is historical evidence indicating that a buy in is probable. Because there is a chance that the Government may be forced to make source selection ultimately on the basis of price alone, an additional source selection criterion is required to ensure that the Government will receive the greatest value. By making source selection solely on the basis of price, the Government may be agreeing to a contractual arrangement

that may ultimately escalate in cost and price, if a buy in has been successful.

Marginal analysis should be used to determine the efficiency of offerors, by comparing their relative ratios of marginal product to the respective prices for resources used. An offeror whose efficiency is evaluated higher that a competitor can then be assumed to offer a greater value, as his costs would grow comparatively less over time.

C. RECOMMENDATIONS FOR FURTHER RESEARCH

1. Further research is needed in the area of developing production functions for individual firms.
2. The application of marginal analysis to contract proposals should be further demonstrated through computer applications.

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D644235 Donaldson
c.1 An analysis of cost analysis methods used during contract evaluation and source selection in government contracting.